## XXVI. *Notice of several recent Discoveries in the Structure and Economy of Spiders. By John Blackwall, Esq. F.L.S.*

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Among the various species of Spiders which capture their prey by means of snares composed of the animal secretion emitted from their spinners, it would be difficult to select any, the Geometricians alone excepted, whose structure and economy are better deserving of investigation than those of *Clubiona atrox*. Whoever inspects closely the web of this very common species, cannot fail to be struck with the singularity of its appearance, and will naturally feel a desire to be made acquainted with the process employed in its formation. Such, at least, has been the case with myself; and I have experienced no small degree of disappointment, in not being able to obtain any information on the subject from those authors whose works I have had an opportunity of consulting. This unsuccessful examination of the labours of naturalists, many of them distinguished for the extent of their learning, the minuteness of their researches, and the comprehensiveness of their views, induces me to believe it probable that the inquiry may not have had that attention bestowed upon it which it undoubtedly merits. As it is one, however, which for some time past has occasionally occupied a portion of my leisure hours, I shall proceed to detail the results of my observations; trusting that if they should not possess that

novelty which, notwithstanding my limited knowledge of the writings of foreign zoologists, I am disposed to claim for them, still they will not be found wholly devoid of interest.

The favourite haunts of *Clubiona atrox* are the branches of trees and shrubs growing against buildings; crevices in old walls; and the corners of windows. In these and similar localities it fixes its residence and fabricates its snare. On the objects surrounding the spot selected for its retreat, it extends to a considerable distance, but without any apparent regularity of design, a number of fine shining lines intersecting each other at various angles, to which it attaches other lines, or rather fasciculi of threads, of a more complicated structure, and of a pale blue tint, nearly approaching the colour of skimmed milk. These compound threads, or flocculi, which in exposed situations retain their delicate hue for a short period only, (old webs being generally of a dull or sullied white, not at all advantageous to their appearance,) are arranged on the first-spun glossy lines both in longitudinal and transverse directions. When recently produced, they adhere strongly to such insects as come in contact with them, and, though perfectly inelastic, may be drawn out into fibres of extreme tenuity. A communication between the snare of this spider and its retreat is established by means of a funnel-shaped tube of a slight texture, whose smaller extremity is in immediate connection with the latter, and, indeed, sometimes constitutes the animal's abode. Not unfrequently two or more tubes occur in the same web, by one or other of which the spider usually effects its retreat when disturbed.

If a newly formed flocculus be minutely examined under the microscope, with a pretty high magnifying power, it will be found to consist of six lines, presenting an appearance similar to that represented by TAB. XXXI. Fig. 1. Two of these filaments are straight

straight and exceedingly attenuated; and upon each of them is disposed a tortuous white line inflected into short curves and loops like a ravelled thread of fine silk. A pale blue band, thickly distributed on each of the inflected lines in numerous irregular curvatures, completes the flocculus. The flexures of the pale blue bands are more widely extended than those of the white tortuous lines on which they occur, and to them the adhesive property of the snare is chiefly to be ascribed. In attempting to determine by experiment the cause of adhesion in the blue bands, I ascertained that bodies with highly polished surfaces, such as the bulbs of thermometers and burnished metallic rods, if carefully applied to them, may be withdrawn without deranging their structure, though the viscid globules in the nets of Geometric Spiders adhere to the same bodies as soon as they are brought into contact with them. From this circumstance I was led to infer that the blue bands are fibrous, although their structure is so exceedingly fine that I cannot detect it even with the assistance of the microscope; and that the imperceptible filaments of which they are composed adhere to objects, not in consequence of being glutinous, but solely by attaching themselves to inequalities on their surfaces. The following brief description of the manner in which the flocculi are fabricated, and of the curious apparatus employed in the process, gives additional weight to this opinion.

There are on the upper joint of the tarsi of the posterior legs of *Clubiona atrox* two parallel rows of spines, moveable at the pleasure of the animal, which may readily be discerned by means of a lens having a magnifying power of ten or twelve. They are situated upon a prominent ridge on the abdominal side of the superior region of the joint, commencing just below its articulation with the tibia, and terminating in a strong spur near its lower extremity. The spines composing the upper row

have a considerable degree of curvature, and taper gradually to a fine point; those of the lower row being stronger, more closely set, and less curved. Inclined towards each other, the two sets, in the performance of their functions, describe a series of acute angles whose vertices are directed down the joint. This important appendage constitutes a striking specific character, which ought on no account to be omitted in descriptions of *Clubiona atrox*.

When the spider purposes to form a flocculus, it presses its spinners against one of the glossy lines composing the foundation of its snare, and emitting from them a small quantity of liquid gum, attaches to it several fine threads, drawn out by advancing the abdomen a little, and kept distinct by extending the mammulæ laterally. The foot of one of the hind-legs is then applied to the superior part of the upper tarsal joint of the other hind-leg, a little above its articulation with the lower joint of the tarsus, and the curious apparatus of spines, above described, is brought immediately beneath the spinners at right angles with the line of the abdomen. By a slight extension of the joints of the hind-legs the apparatus is forced backwards across the mammulæ, the diverging extremities of which it touches in its transit, and is restored to its former position by a corresponding degree of contraction in the joints. In proportion to the continuation of this process, (and it is not at all unusual for the spider to pass its spiny apparatus across the points of the mammulæ several hundred times in rapid succession,) the inflected lines of the flocculus are found to be produced, the spider making room for them as they accumulate, by elevating and at the same time advancing the abdomen in a small degree, which it effects by slightly extending the joints of the third pair of legs, and contracting those of the two anterior pair. As this operation is generally accomplished in the night,

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it can seldom be seen to advantage, unless artificial light be employed, some skill in the management of which is required in order to avoid disturbing the spider. The *modus operandi*, as nearly as I can ascertain it by the most diligent observation, appears to be this. The points of the lower row of spines are protruded between those of the upper row, and in passing across the extremities of the mammulæ comb out the tortuous lines, which run into numerous flexures in consequence of not being kept fully extended. The purpose subserved by the upper row of spines seems to be the extrication of the tortuous lines from the spines of the lower row, by a slight motion outwards, which disengages their points. Now, were the blue bands glutinous, this mode of proceeding would be quite unavailing; it is only on the supposition, therefore, that they have a fibrous structure, that their adhesive property can be satisfactorily explained. When a sufficient quantity of the inflected filaments is produced, the spider again applies its spinners to one of the glossy lines, and attaches the flocculus to it. In this manner it proceeds with its labours, occasionally employing the combing apparatus of both hind-legs, till the web is completed. Should any of the flocculi be destroyed, or rendered almost useless by having their adhesive property impaired, new ones are constantly added to the snare.

A more exact idea of the mechanism of the combing apparatus than can be conveyed in words, will be obtained by inspecting the accompanying plate (Tab. XXXI.).

Naturalists appear to concur in the opinion, that the tarsi of spiders are armed at their extremities with three claws, which occupy the upper and anterior portion of the foot. That this is the case with some species cannot be denied; other species, however, belonging to various genera, *Mygale avicularia*, *Drassus melanogaster*,

*lanogaster*, and *Salticus scenicus*, for example, have only *two claws* on each foot; and if the tarsi of the larger Geometric Spiders indigenous to Great Britain, such as *Epeira cicatricosa*, *Epeira Diadema*, and *Epeira apoclisa*, be examined under the microscope with a high magnifying power, it will be distinctly perceived that the inferior part of their feet is provided with several claws, which have a considerable degree of curvature, are finely pointed, and are furnished with tooth-like processes on the under side (Tab. XXXI. Fig. 4.); and should the investigation be extended to other retiary spiders, the feet of many species which construct complicated snares will likewise be found to exhibit a similar organization. As the best means of guarding against errors, to which the inspection of limbs defective in structure might conduce, it is advisable to select the legs of vigorous individuals which have recently moulted, whenever such can be procured.

The supernumerary claws were first observed by me in examining the feet of *Epeira apoclisa;* and in every instance I counted as many as five, which, with the three upper ones previously known, give a total of *eight claws* on the same foot, distinguishable at a glance from the coarse setaceous bristles in their vicinity. There is also a strong moveable spine inserted near the termination of the tarsus of each posterior leg on the under side, which curves upwards at its extremity, and exhibits a slight irregularity of outline at its superior surface. The function performed by these spines is an important one. By the contraction of their flexor muscles they are drawn towards the foot, and are thus brought in immediate opposition to the claws, by which means the animal is enabled to hold with a firm grasp such lines as it designs to attach itself to. Now, as the spines and the spinning apparatus are the most efficient instruments

instruments employed by the Geometric Spiders for the purpose of suspension, it is obvious why they usually direct their heads downwards when they occupy the centre of their nets.

As several difficulties present themselves in the prosecution of these researches, occasioned chiefly by the impracticability of comprising all the claws in one distinct view; and as I have not yet succeeded in procuring instruments of sufficient delicacy to enable me to accomplish the dissection of exceedingly minute objects under the microscope, I cannot completely satisfy myself at present whether the number and arrangement of the additional claws are uniformly the same on the feet of such spiders as I have ascertained to be supplied with them; though as regards the larger species I am thoroughly convinced that this is the case, and I have reason to think that it will ultimately prove to be so with the rest. In pursuing the inquiry, these particulars, of course, will claim my especial attention.

It is not at all surprising that the Geometricians, which employ their feet in the fabrication of complicated nets, should have them more amply provided with claws than those species which use theirs principally as instruments of progression. An estimate of the number of viscid globules distributed on the elastic spiral line in a net of *Epeira apoclisa* of a medium size, will convey some idea of the elaborate operations performed by the Geometric Spiders in the construction of their snares*. The mean distance between two contiguous radii in a net of this species, is about seven tenths of an inch; if, therefore, the number 7 be multiplied by 20, the mean number of viscid globules which occur on one tenth of an inch of the elastic spiral line at the ordinary degree of tension, the product will be 140,

*For a circumstantial account of the manner in which the Geometric Spiders construct their nets, see the *Zoological Journal*, vol. v. p. 181. et seq.

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the mean number of globules deposited on seven tenths of an inch of the elastic spiral line; this product multiplied by 24, the mean number of circumvolutions formed by the elastic spiral line, gives 3,360, the mean number of globules contained between two radii; which multiplied by 26, the mean number of radii, produces 87,360, the total number of viscid globules in a finished net of average dimensions. A large net, fourteen or sixteen inches in diameter, I have found, by a similar calculation, to contain upward of 120,000 viscid globules, and yet *Epeira apoclisa* will complete its snare in about forty minutes, on an average, if it meet with no interruption. Astonishingly great as this number of globules is, each is separated from those adjacent to it by a sensible space; indeed the material of which they are composed is so fluid, that they run together the moment they are brought into contact. The globules and the intervals between them may be distinctly seen with the assistance of a magnifier of the power of ten; and it would appear from the following passage extracted from *Micrographia*, p. 202, that they did not escape the notice of Dr. Hooke. "I observed further," he informs us, "that the radiating chords of the web were much bigger and smoother than those that were woven round, which seemed smaller, and all over knotted or pearled with small transparent globules, not unlike small crystal beads or seed pearls, thin strung on a clew of silk; which, whether they were so spun by the spider, or by the adventitious moisture of a fog (which I have observed to cover all these filaments with such crystalline beads), I will not now dispute."

Messrs. Kirby and Spence, in their *Introduction to Entomology*, vol. i. Letter xiii. state that "the net of the garden spider is composed of two distinct kinds of silk; that of the radii not adhesive, that of the circles extremely viscid:" and this difference, they remark, "when it is considered that both sorts

sorts proceed from the same instrument, is truly wonderful." The fact, however, is even more extraordinary than it is represented to be by those distinguished naturalists; for not only the garden spider, but every geometric species with which I am acquainted, employs *three* distinct kinds of silk, if a liquid gum can with propriety be termed silk, in the construction of its net. The boundary lines, radii, and first formed spiral line being unadhesive, and possessing only a moderate share of elasticity, are evidently composed of a different material from the last formed spiral line, which is exceedingly viscid, and elastic in a remarkable degree. Now, the viscidity of the elastic spiral line may be shown to depend entirely upon the globules with which it is studded; for if they be removed by careful applications of the finger, a fine glossy line remains, which is highly elastic, but perfectly unadhesive. As the globules, therefore, and the line on which they are disposed differ so essentially from each other, and from the rest of the snare, it is reasonable to infer that the physical constitution of these several portions of the net must be dissimilar.

When exposed to the desiccating influence of the sun, and of air briskly agitated, the nets of geometric spiders speedily lose their adhesive property; but when formed in situations from which light is excluded, and where the atmosphere is not liable to be perceptibly disturbed, I have known them retain their viscidity for a long period. In a net of *Epeira Diadema* constructed in a glass jar, which was placed in a dark closet where the temperature was not subject to great or sudden fluctuations, the globules preserved their adhesive power almost unimpaired, and the last-formed spiral line its elasticity for more than seven months.

The belief that spiders are incapable of ascending the perpendicular surfaces of polished bodies without the assistance of

lines emitted from their spinners is so widely extended, that an attempt to prove its fallacy in particular cases will, in all probability, be received with some distrust: nevertheless, the fact that several species have the power of traversing vertical panes of window-glass in any direction whatever, unsupported by a single filament, may be easily confirmed by experiment. Among the British spiders observed to ascend with facility well cleansed windows, and the sides of glass jars in which they have been confined, I may name *Drassus melanogaster* and *Salticus scenicus*. The latter species is extensively known, and may be readily procured in warm sunny weather in summer, on the walls of old buildings having a southern aspect.

On examining the legs of these animals under the microscope, with a view to discover the means by which they support themselves against gravity, I perceived that the tarsi are provided on the underside with numerous appendages curving downwards, which are slender at their bases and dilated towards their extremities. The idea immediately occurred to me that these appendages may perform the office of suckers, and that the spiders are probably enabled to adhere to the upright sides of smooth objects by atmospherical pressure; but being sensible that mere conjecture, however plausible it may appear, is the bane of Natural History, I resolved to investigate the subject experimentally. Having obtained spiders of the above-named species, in various stages of growth, I found that the larger individuals experienced greater difficulty in ascending glass than the smaller ones, which in numerous instances were capable of moving slowly on an ordinary window-pane, even in an inverted position, or with the back downwards. It was evident also that physical strength (other conditions being the same) gave its possessor a decided advantage in this respect. When highly polished glass of a superior quality was employed, the difficulty was considerably

siderably increased; and in all cases, those spiders effected an ascent with the greatest effort, which, in proportion to their bulk, had the inferior surface of their tarsi most sparingly furnished with the requisite apparatus. These results, some of which are in direct opposition to the hypothesis I had previously entertained, determined me to inspect the tarsal appendages more minutely than I had hitherto done; and a peculiarly favourable opportunity unexpectedly presented itself. Three living specimens of *Mygale avicularia* having been brought accidentally to Manchester in dye-woods imported from the West India Islands during the present year (1830), I availed myself of the circumstance to examine under the microscope the appendages with which the tarsi of this gigantic species are so abundantly supplied; conceiving that their structure would be exhibited to greater advantage in a recent subject than in individuals which have long occupied a place in the cabinet. In this expectation I was not disappointed; and I shall now proceed to describe the organism of the appendages, which is much more complex than I had anticipated.—Each consists of a slender bristle fringed on the sides with exceedingly fine hairs gradually diminishing in length as they approach its extremity, where they occur in such profusion as to form a thick brush on its inferior surface, giving the part that dilated appearance already alluded to. This structure, as far as my researches extend, is common to the tarsal appendages of those spiders which are able to ascend the perpendicular sides of smooth bodies without supervenient aid; and the minute bristles with which the tarsal cushions of many insects, remarkable for their ability to walk up glass, are furnished, appear to possess an organization closely analogous.

The hold upon objects which the setaceous bristles give to the spiders provided with them seems to be purely mechanical, depending, in a great measure, on the numerous points of con-

tact they present. At a very low estimate, there are on the slender bristles which form the brushes occurring on the inferior part of the tarsi, and the terminal joint of the pediform palpi of adult females of the species *Mygale avicularia*, more than 6,000,000 hairs of extreme delicacy, a large proportion of which can be applied by the spider to bodies with plain surfaces. If the finger be drawn gently along the underside of the tarsi, from their extremities towards the tibiæ, they will be found to adhere powerfully to the cuticle; the sensation occasioned by this proceeding exciting in the mind the idea that they are smeared with some viscous matter. There can be no doubt, therefore, that the influence they exercise is in the direction indicated by this observation. A setaceous bristle from one of the tarsi of *Mygale avicularia*, very highly magnified, is represented by Fig. 5; and care must be taken not to confound these tarsal appendages with the compound hairs which clothe the limbs of some spiders (*Aranea domestica* in particular), one of which is represented by Fig. 6, on a large scale.

Dr. Leach, in treating upon spiders in the article *Annulosa*, published in the *Supplement to the Encyclopædia Britannica*, p. 435, remarks that "when about to cast their covering, they suspend themselves in some corner, and creep out of a crack which takes place on their back, gradually withdrawing their legs from the skin, as if from a glove." With deference to so accomplished a zoologist, I may be allowed to observe that this statement is not in strict accordance with my own experience; and as I do not remember to have met with a satisfactory account of the moulting of spiders in the course of my reading, I shall endeavour to elucidate this curious subject, by giving such particulars relative to it as have fallen under my notice.

Considering the apparent uniformity of the process by which this important change in the external condition of spiders is effected,

effected, it will suffice to detail the proceedings of a single species; and as *Epeira calophylla* is of frequent occurrence about retired buildings situated in the country, and, consequently, may be procured without difficulty, I shall select it for the purpose. Preparatory to casting its integuments, this spider spins several strong lines in the vicinity of its snare, from which it suspends itself by the feet and a filament proceeding from the spinners. After remaining for a short time in this situation, the corneous covering of the thorax gives way,—not in the medial line of the dorsal region, as Dr. Leach's statement would seem to imply, but laterally, disuniting immediately above the insertion of the mandibles and legs, so that the head and thorax are the first parts liberated. The line of separation pursues the same direction till it extends to the abdomen, which is next disengaged; the extrication of the legs being the last and greatest difficulty which the spider has to overcome. As the suspensory filament connected with the spinners of the exuviæ is considerably shorter than the legs, and does not undergo any sensible alteration in length, the abdomen, during the process of moulting, becomes gradually deflected from its original horizontal direction, till it assumes a vertical position nearly at right angles with the thorax. By this change of posture, attended with numerous contortions of the body and alternate contractions and extensions of the limbs, the spider is ultimately enabled to accomplish its purpose. The spines with which the legs are provided no doubt contribute to facilitate the operation greatly; for as they are directed down the limbs, and are moveable at the will of the animal, when it has partially withdrawn the legs from their sheaths by contracting them, it can prevent them from re-entering by slightly erecting the spines and thus bringing their extremities in contact with the inner surface of the integuments. When the spider has completely disengaged itself from

from the slough, it remains for a short period in a state of great exhaustion, suspended solely by a thread from the spinners connected with the interior of the abdominal portion of the cast skin, which is much corrugated and drawn together. The entire process, as above described, occupies the space of about twenty minutes. After reposing a little, the spider further attaches itself to the suspensory lines by the claws of the feet; and when its strength is sufficiently restored, and its limbs have acquired the requisite degree of firmness, it ascends its filaments and seeks its retreat.

Having frequently witnessed the moulting of spiders in their natural haunts, and also in a state of captivity, and having carefully examined the cast skins of numerous species belonging to the genera *Epeira*, *Theridion*, *Aranea*, *Clubiona*, *Drassus*, *Salticus*, *&c.*, in the precise situations and under the same circumstances, apparently, in which they have been left by their former occupiers, I am thoroughly persuaded that the process is a very uniform one.

Intimately connected with the renovation of the integuments is the reproduction of the limbs of spiders. For this interesting discovery we are indebted to the late Dr. C. Heineken, whose investigations relative to the subject are published in the *Zoological Journal*, vol. iv. p. 284 & 422 ; and I am happy to bear testimony to the general accuracy of his conclusions.

The reproduction of the palpi does not appear to have been noticed by Dr. Heineken ; but that these members, after suffering mutilation, are restored in the same manner as the legs, I have clearly proved by repeated experiments. That mutilated members are not always reproduced at a subsequent moulting, even when it takes place at a period considerably after the infliction of the injury, is rendered evident by the following remarkable fact. On the 13th of July, 1830, a male specimen of